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(54) Title of the Invention: LIQUID CRYSTAL DISPLAY DEVICE

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(57) Abstract
[Constitution] Hard coat films 3a to 3d, which contain siloxane are formed over both sides of plastic substrates 2a and 2b and SiO_x films 4a and 4b are formed over sides of the respective plastic substrates 2a and 2b facing each other by sputtering. Further, transparent electrode layers 5a and 5b each of which is formed of an ITO film, and alignment films 6a and 6b are formed in this order over the SiO_x films 4a and 4b, and a liquid crystal layer 8 is formed between the plastic substrates 2a and 2b.
[Effect] The adhesiveness between the plastic substrates 2a and 2b is improved, and generation of cracks is decreased in transparent electrode layers 5a and 5b, while a gas shutting capability of the plastic substrates 2a and 2b is remarkably improved. Therefore, generation of air bubbles is decreased in the liquid crystal layer 8. Accordingly, a liquid crystal display device which has high display quality and high reliability can be realized.

Specification
1. [Title of the Invention]
LIQUID CRYSTAL DISPLAY DEVICE
2. [Scope of Claim]
1) A liquid crystal display device provided with transparent electrode layers over respective sides of a pair of plastic substrates facing each other with a liquid crystal layer interposed therebetween, characterized in that:
hard coat films containing siloxane are provided over both sides of the pair of plastic substrates respectively, and an SiO_x film is provided over one side of the pair of the plastic substrates respectively.
3. Detailed Description of the Invention
[0001]

[Industrial Field of the Invention] The present invention relates to a liquid display device used as a display device in OA (Office Automation) apparatuses such as a laptop or palmtop personal computer and a word processor.

[0002]

[Prior Art] In recent years, reflecting the weight saving and downsizing trend of OA apparatuses toward notebook size, palmtop size, or the like, a liquid crystal display device used as a display device of such an OA apparatus has been desired to be reduced in thickness and weight. Therefore, a liquid crystal display device using a plastic substrate becomes to be used for OA apparatuses such as a laptop or palmtop personal computer or a word processor.

[0003] For such a liquid crystal display device, a pair of plastic substrates containing PES (Polyether sulphone) are generally used, and the pair of plastic substrates are provided with a gas barrier layer containing PVA (Polyvinyl alcohol), a transparent electrode layer containing an ITO (Indium-tin oxide) film, an alignment film, and the like. Then, the pair of plastic substrates are adhered to each other by a sealing material with a liquid crystal layer interposed therebetween so that a liquid crystal display device is constructed.

[0004] However, since the abovementioned plastic substrates containing PES are fabricated by an extrusion forming method, there is a defect that sufficient surface smoothness cannot be obtained. Therefore, it is known that such plastic substrates containing PES are unsuitable for an STN (Super Twisted Nematic) liquid crystal display device substrate which requires a highly defined surface (approximately 0.01 μm/mm or less).

[0005] The above STN liquid crystal display device has been reduced in size and weight by using a molded plastic substrates having a highly defined surface formed of an acrylic resin, an epoxy resin, or the like so far.

[0006]

[Problems to be Solved by the Invention] However, the substrates of the conventional liquid crystal display device using the plastic substrates formed of an acrylic resin, an epoxy resin, or the like are not sufficiently adhered to each other because of the quality of the substrate so that it is concerned that cracks may be generated in a transparent electrode layer formed

of an ITO film by performing a wet processing using alkalis such as sodium hydroxide when patterning an ITO film or thermal treatment such as baking of an alignment film in the manufacturing steps, or aging or the like under the condition of high temperature and high humidity (for example, 40°C, 95%$_{RH}$) after completion of a liquid crystal display device.

[0007] Further, there is another defect that a plastic substrate cannot shut gas sufficiently so that gas enters a liquid crystal layer through the plastic substrate by performing aging under the condition of high temperature and high humidity after completion of the liquid crystal display device as mentioned above, thereby air bubbles are generated in a liquid crystal layer.

[0008]

[Means for Solving the Problem] Therefore, it is a problem that a liquid crystal display device with high display quality and high reliability is difficult to realize, because of the abovementioned reasons so far.

[0009] The invention is made in view of the prior problems to improve display quality and reliability of a liquid crystal display device such as an STN type, which requires a highly defined surface for example, as well as to realize reduction in size and weight of the liquid crystal display device by using a plastic substrate.

[0010]

[Means for Solving the Problem] A liquid crystal display device provided with transparent electrode layers over respective sides of a pair of plastic substrates facing each other disposed with a liquid crystal layer interposed therebetween is characterized in that hard coat films containing siloxane are provided over both sides of each of the pair of the plastic substrates while an SiO_x film is provided over one side of the respective pair of plastic substrates.

[0011]

[Operation] Hard coat films containing siloxane are provided over both sides of the respective pair of plastic substrates which interpose a liquid crystal layer therebetween, in addition, an SiO_x film is provided over one side of the respective pair of plastic substrates.

[0012] Therefore, substrates are adhered well to each other so that even when performing a

wet processing using alkalis such as sodium hydroxide in patterning a transparent electrode layer, or a thermal treatment such as baking of an alignment film in the manufacturing steps of a liquid crystal display device, or aging or the like under the condition of high temperature and high humidity (for example, 40ºC, 95%$_{RH}$) after completion of a liquid crystal display device, cracks are hardly generated in the transparent electrode layer.

[0013] Further, even if a plastic substrate has a low gas shutting capability, gas is prevented from entering a liquid crystal layer by employing the liquid crystal display device having the abovementioned constitution. Therefore, even if aging or the like is performed under the abovementioned condition of high temperature and high humidity after completion of a liquid crystal display device, air bubbles to be generated in the liquid crystal layer decrease.

[0014]

[Embodiments] An embodiment of the invention is described below, based on FIG. 1 with an STN liquid crystal display device given as an example.

[0015] As shown in FIG. 1, in a liquid crystal display device 1 in accordance with this embodiment, a pair of plastic substrates 2a and 2b, which contain an acrylic resin, for example are disposed with a liquid crystal layer 8 interposed therebetween. A hard coat films 3a to 3d, which contain siloxane is formed over both top and bottom sides of the pair of the plastic substrates 2a and 2b. An SiO_x films 4a and 4b, transparent electrode layers 5a and 5b, each of which is formed of an ITO film, and alignment films 6a and 6b are provided sequentially over the hard coat films 3b and 3c which are provided over the respective sides of the plastic substrates 2a and 2b facing each other.

[0016] Further, the liquid crystal layer 8 between the alignment films 6a and 6b is sealed by a sealing material 9 provided in the peripheral portion of the respective sides of the plastic substrates 2a and 2b facing each other. The measurement between the plastic substrates 2a and 2b is kept constant by spacers 7. In addition, polarizing plates 10a and 10b is adhered to hard coat films 3a and 3b which are provided over the opposite sides of the respective sides of the plastic substrates 2a and 2b facing each other.

[0017] In the abovementioned constitution, a manufacturing process of the liquid crystal display device 1 is described below.

[0018] First, after 2 plastic substrates 2a and 2b are dipped in a solution in which siloxane hard coat agent is dissolved, the hard coat films 3a to 3d, which contain siloxane are formed in thickness of 2 to 3 μm over both sides of the plastic substrates 2a and 2b by pulling the plastic substrates 2a and 2b up. Then, SiO_x films 4a and 4b of 100 to 1000 Å thick are formed over one side of the plastic substrates 2a and 2b on which hard coat films 3b and 3c are formed respectively by sputtering or the like. Further, ITO films of 500 to 3000 Å thick are formed over the SiO_x films 4a and 4b by sputtering or the like, and transparent electrode layers 5a and 5b are formed, and the ITO films are patterned to have a predetemined shape by etching or the like so that transparent electrode layers 5a and 5b are formed.

[0019] Subsequently, the alignment films 6a and 6b are formed by baking or the like over sides of the plastic substrates 2a and 2b, over which the transparent electrode layers 5a and 5b are formed respectively. After the sealing material 9 is formed by printing a seal in the peripheral portion of the plastic substrates 2a and 2b, the plastic substrates 2a and 2b is adhered to each other by diffusing the spacers 7 under the condition where respective sides of the plastic substrates 2a and 2b over which the transparent electrode layers 5a and 5b are formed side each other.

[0020] Subsequently, the liquid crystal layer 8 is formed by injecting a liquid crystal material between the plastic substrates 2a and 2b and sealing it. After that, the STN liquid crystal display device 1 having a twist angle of 240 degrees, and a cell gap of 6 μm is manufactured by adhering the polarizing plates 10a and 10b to the opposite sides of the respective sides of the plastic substrate 2a and 2b facing each other.

[0021] With respect to the liquid crystal display device 1 manufactured as described above and the conventional liquid display device, after aging is performed under the condition of high temperature and high humidity (for example, 40ºC, 95%$_{RH}$), the amount of O_2 and H_2O that permeate in the liquid crystal layer is measured respectively so as to compare gas shutting capability with respect to O_2 and H_2O. Note that each of the measurement results is shown in Table 1.

[0022]

[Table 1]

	Embodiment	Prior Art
O_2 permeation amount	0.2 cc/m^2·24Hr·atm	0.5 to 1.0 cc/m^2·24Hr·atm
H_2O permeation amount	0.1g/m^2·24Hr	Several g/m^2·24Hr

[0023] As is clear in Table 1, the liquid crystal display device 1 of this embodiment has a high gas shutting capability in comparison with the conventional liquid crystal display device so that it is found that air bubbles are hardly generated in the liquid crystal layer 8.

[0024] As mentioned above, in the liquid crystal display device 1 of this embodiment, the hard coat films 3a to 3d, which contain siloxane are formed over both sides of the plastic substrates 2a and 2b. in addition, after the SiO_x films 4a and 4b are formed over respective sides of the plastic substrates 2a and 2b facing each other, the transparent electrode layers 5a and 5b are formed.

[0025] Accordingly, the adhesiveness between the plastic substrates 2a and 2b is improved so that cracks in the transparent electrode layers 5a and 5b can be reduced, which are often generated in the case of performing a wet processing using alkalis such as sodium hydroxide when patterning the transparent electrode layers 5a and 5b, or a thermal treatment such as baking of an alignment film in the manufacturing steps of the liquid crystal display device 1, or aging or the like under the condition of high temperature and high humidity (for example, 40ºC, 95%$_{RH}$) after completion of a liquid crystal display device.

[0026] Further, the gas shutting capability of the plastic substrates 2a and 2b is remarkably improved so that air bubbles are hardly generated in the liquid crystal layer 8 even if, for example, aging is performed under the condition of high temperature and high humidity after completion of the liquid crystal display device. Therefore, with respect to the STN liquid crystal display device that requires a highly defined surface, the improvement of the display quality and the reliability as well as the reduction in size and weight can be realized.

[0027] Note that, in this embodiment, description is made on the STN liquid crystal display

device as an example, however, the invention can also be applied to a liquid crystal display device which employs another driving method.

[0028]

[Effect of the Invention] In the liquid display device of the invention, the hard coat films containing siloxane are provided over both sides of the pair of plastic substrates, and the SiO_x film is provided over one side of the respective pair of plastic substrates.

[0029] Therefore, the adhesiveness between the plastic substrates is improved so that a crack is prevented from being generated in the transparent electrode layer, and the gas shutting capability of the plastic substrate is remarkably improved so that generation of air bubbles is decreased in the liquid crystal layer. Therefore, by using the STN liquid crystal display device that requires a highly defined surface, such effects can be obtained as the improvement of the display quality and the reliability as well as the reduction in size and weight.

4. [Brief Description of the Drawings]

FIG. 1 is a cross sectional view showing a liquid crystal display device in accordance with an embodiment of the invention.

1 liquid crystal display device

2a·2b plastic substrates

3a·3b hard coat films

4a·4b SiO_x films

5a·5b transparent electrode layers

8 liquid crystal layer